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LAND-IMPROVEMENT MEASURES IN RELATION TO A POSSIBLE CONTROL OF THE BEET LEAFHOPPER AND CURLY TOP[1]

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INTRODUCTION

The purpose of this circular is to show that the application of certain land-improvement measures would result in a large measure of control of the beet leafhopper (*Eutettix tenellus* (Bak.)) and the curly top disease that it transmits. This insect is one of the worst scourges affecting the agriculture of most of the States west of the Rocky Mountains. It not only causes large periodic losses to the sugar-beet, bean, and tomato industries but actually limits very markedly the areas in which these crops can be successfully grown. This limitation is so severe that the growing of crops susceptible to curly top is rendered impossible in many sections otherwise suitable. The nature and extent of the curly top injury resulting from outbreaks of this insect have already been pointed out and discussed at length by other authors[2] and need not be further considered at this time.

[1] Acknowledgment is made to Eubanks Carsner, senior pathologist, Bureau of Plant Industry, and to William C. Cook, entomologist, Bureau of Entomology and Plant Quarantine, for valuable suggestions and criticisms made in connection with the preparation of the manuscript.

[2] BALL, E. D. THE BEET LEAF HOPPER AND THE CURLY-LEAF DISEASE THAT IT TRANSMITS. Utah Agr. Expt. Sta. Bull. 155, 56 pp., illus. 1917.
CARSNER, E. SUSCEPTIBILITY OF THE BEAN TO THE VIRUS OF SUGAR-BEET CURLY-TOP. Jour. Agr. Research 33 : 345–348, illus. 1926.
CARTER, W. ECOLOGICAL STUDIES OF THE BEET LEAFHOPPER. U. S. Dept. Agr. Tech. Bull. 206, 115 pp., illus. 1930.
ANNAND, P. N., CHAMBERLIN, J. C., HENDERSON, C. F., and WATERS, H. A. MOVEMENTS OF THE BEET LEAF HOPPER IN 1930 IN SOUTHERN IDAHO. U. S. Dept. Agr. Circ. 244, 24 pp., illus. 1932.

The economic importance of the beet leafhopper, a plant-feeding, sucking insect, depends not on the damage resulting directly from its feeding but on the virus disease which it transmits. Furthermore, it does not live throughout the year on the cultivated crops which it affects, but rather builds up high populations on noncultivated host plants, chiefly weeds, that occur on nonagricultural lands or on lands that cannot be continuously farmed. These weedy lands constitute the breeding areas of the insect. The cultivated crops are initially infested in the course of a general migration or dispersal from one food plant to another.

BASIS OF PROPOSED CONTROL METHOD

The proposed control is based essentially on the idea that the proper use of lands now intermittently farmed or destructively grazed will hasten the natural replacement of the weed hosts by nonhosts, a process that takes place to a limited extent on these weedy areas even under present conditions. The problem is similar in all of the States west of the Rocky Mountains, hence the essentials of the control may be applied throughout these States.

The detailed studies upon which the following discussion is based were made in southern Idaho. The accompanying map (fig. 1) indicates in a general way the affected portions of the State by showing the present sugar-beet-growing districts and the known leafhopper-breeding areas. It does not, however, show the much larger acreage that would be made available for susceptible crops by the control of the beet leafhopper and curly top.

SEQUENCES OF PLANT HOSTS REQUIRED BY LEAFHOPPER

From the standpoint of control it is important that the beet leafhopper must have a continuous sequence of food plants throughout the year in order to maintain itself from season to season. In the ordinary development of leafhopper populations such a continuous sequence depends upon three different sets of plants, since in general there are no perennials capable of serving as both breeding and food plants throughout the year. The first set of plants carries the insect through the fall-winter-spring period and the next set through the summer period. However, the growing period of these two sets of plants always overlaps in the spring, permitting the insect to go from the first to the second, but where fall rains are scanty there is a gap in the fall when summer annuals are dead and winter annuals have not germinated. During this period a third set of plants, functioning as hold-over hosts, is necessary to carry the insect until winter annuals germinate.

Various plants serve as spring hosts in different parts of the West. In Idaho these are chiefly mustards, the most important being tumblemustard (*Norta altissima* (L.) Britton), green tansymustard (*Sophia longipedicellata* (Fourn.) Howell), and flixweed (*Sophia parviflora* (Lam.) Standl.). The mustards germinate in the late fall and the leafhopper feeds and later overwinters upon these plants. In the spring, the leafhopper continues its activities upon these plants and builds up large populations. With the maturing or drying of the host plants in May and June, the insects disperse to the summer weed hosts.

Of the summer weed hosts in Idaho, the Russian-thistle (*Salsola pestifer* A. Nelson) is by far the most important and is also common

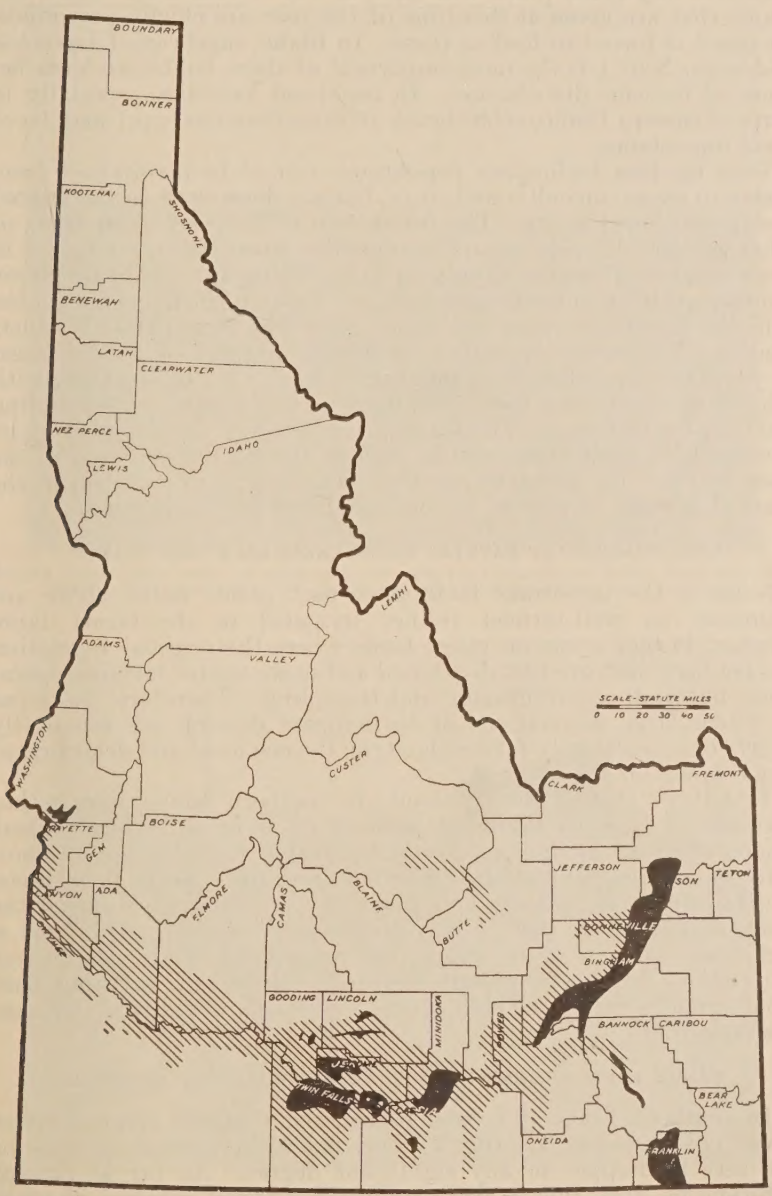

FIGURE 1.—Map of Idaho, showing the present sugar-beet-growing areas (black) and the leafhopper-breeding areas (shaded).

to all of the areas in the Western States, excepting portions of Arizona. With the maturing and drying of the summer hosts, the

leafhoppers move to the hold-over hosts, except in those cases where there has been an early germination of winter-spring host plants.

Almost any green plant will serve as a hold-over host. Since the plants that are green at this time of the year are chiefly perennials, the insect is forced to feed on these. In Idaho, sagebrush (*Artemisia tridentata* Nutt.) is the most important of these hold-over hosts because of its wide distribution. In restricted localities, especially in parts of eastern Idaho, rabbitbrush (*Chrysothamnus* spp.) may be of equal importance.

Thus the beet leafhopper populations cannot be maintained from season to season on cultivated crops, but are dependent on the annual weeds mentioned above. The infestation of fields of sugar beets or other susceptible crops occurs incidentally when the insect moves in large numbers from the drying spring-growing annuals to the green summer-growing annuals, especially the Russian-thistle. Once in the field the insects carrying the virus infect the crop plants by their feeding. The rate of spread of the disease and the severity of losses in yield are dependent on a number of factors. For instance, with other factors constant, yields will decrease as the number of invading leafhoppers increases. The losses in yields vary; in the good years average sugar-beet yields run as high as 16 tons per acre and in the poor years as low as 5 tons per acre. In the poor years much of the planted acreage is plowed up or abandoned before harvest.

WELL-FARMED AND NATURAL RANGE LANDS LACK HOST PLANTS

None of the important leafhopper host plants noted above are abundant on well-farmed (either irrigated or dry-farm) land. Neither do they occur on range lands where the original vegetation has not been destroyed by ill-advised and unsuccessful farming operations, burning, or overgrazing and trampling. Therefore, the areas in which large populations of leafhoppers develop are essentially poorly or speculatively farmed lands on the one hand and deteriorated range lands on the other.

It follows that if all the lands in southern Idaho were either successfully and continuously farmed or were in natural desert range, the beet leafhopper would be unable to build up economically dangerous populations. Furthermore, since, aside from beets, Russian-thistle is the only host plant of any importance during the summer, it is clear that if this plant could be eliminated from a significant portion of its range, the magnitude of the leafhopper populations would be greatly reduced. Moreover, anything that would greatly reduce the abundance of mustards would tend to insure the same result.

RANGE IMPROVEMENT IMPORTANT IN CURLY TOP CONTROL

In southern Idaho it is well established that the original plant cover, chiefly perennials (fig. 2), does not include breeding hosts of the beet leafhopper to any significant degree. As far as present information goes, this is also true of the affected portions of other States. Furthermore, these native plants are capable, except under misuse, of replacing the weed hosts concerned (fig. 3). Therefore, if the lands which are now poorly or not continuously farmed can be

restored to their original status of good range land and if the rehabilitation of deteriorated range land (fig. 4) can be accomplished, it

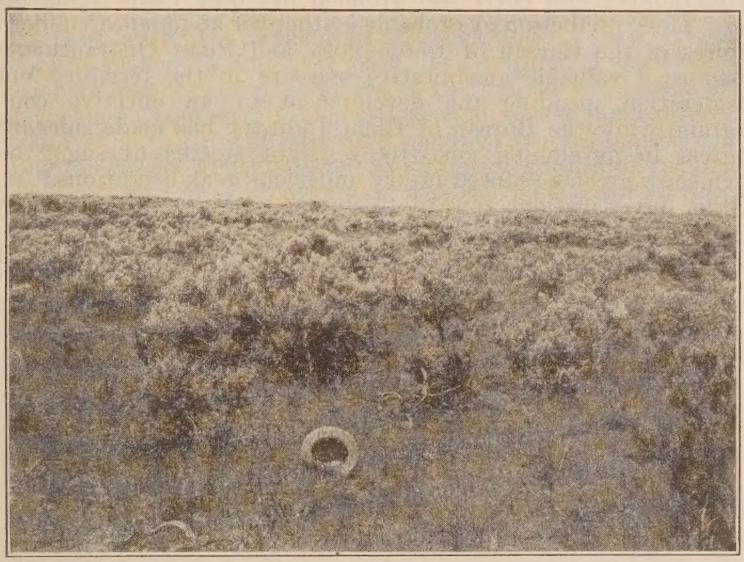

FIGURE 2.—A plant cover of sagebrush and perennial grasses, of which Sandberg bluegrass is most abundant. (Photographed near Hansen, Idaho, June 16, 1935.)

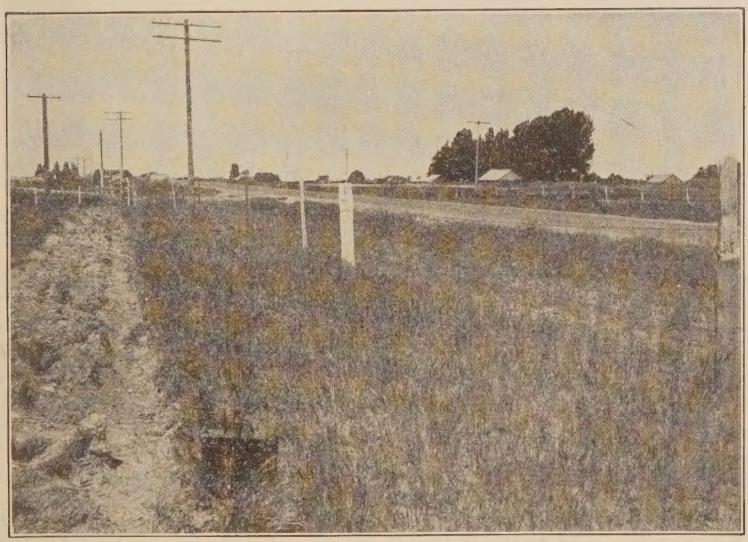

FIGURE 3.—A uniform stand of Sandberg bluegrass between the fireguard and fence along a railroad right-of-way. Along the highway to the right of the fence is a stand of tumblemustard. (Photographed near Hansen, Idaho, June 16, 1935.)

is clear that the beet leafhopper will be largely controlled because of the lack of suitable food and breeding plants.

OTHER WORK ON CURLY TOP CONTROL

It is recognized, of course, that much progress toward a solution of the leafhopper and curly top problem has been made along other lines. Thus, prediction of probable leafhopper abundance,[3] under the auspices of the Bureau of Entomology and Plant Quarantine, has served as a valuable ameliorative measure in the territory under consideration, pending the development of an effective control program, while the Bureau of Plant Industry has made substantial progress in developing curly-top-resistant strains of sugar beets which show greatly reduced injury under outbreak conditions.[4]

Other investigations toward this same end are now under way at various places, especially in California, but the data are not as yet published and are not, therefore, considered at this time. The

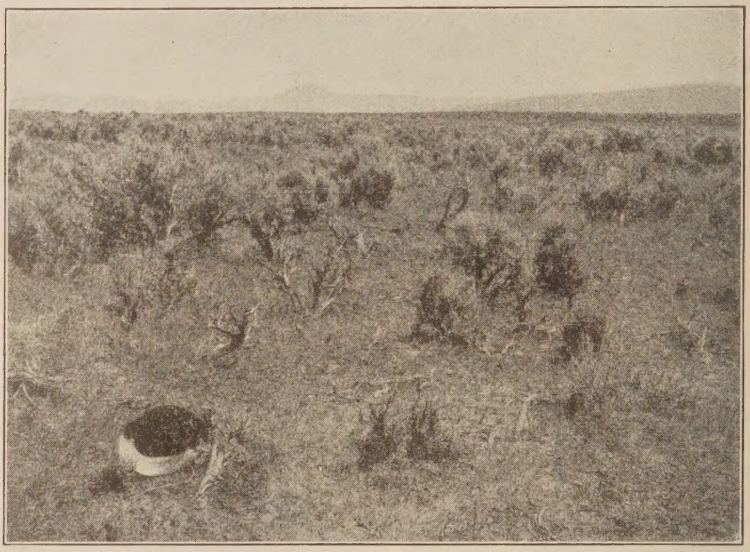

FIGURE 4.—A plant cover of poor sagebrush with many dead bushes and green tansymustard now mature and dry. (Photographed near Hansen, Idaho, June 16, 1935.)

above-mentioned prediction service, while of substantial ameliorative value, cannot be considered in any sense as a control measure, while the curly-top-resistant beets thus far developed still suffer sufficient damage under outbreak conditions to make the problem of final control important. Finally, even if an immune beet is developed, the damage to other crops would be sufficient to justify the application of the proposed program.

INFORMATION UPON WHICH THE PROGRAM IS BASED

In this presentation no attempt will be made to discuss in detail the data upon which the following generalizations are based. Some

[3] CARTER, W. See footnote 2.
ANNAND, P. N., CHAMBERLIN, J. C., HENDERSON, C. F., and WATERS, H. A. See footnote 2.

[4] CARSNER, E. CURLY-TOP RESISTANCE IN SUGAR BEETS AND TESTS OF THE RESISTANT VARIETY U. S. NO. 1. U. S. Dept. Agr. Tech. Bull. 360, 68 pp., illus. 1933.

of the statements are now well recognized and generally accepted. They are brought together here to show the relation of one to another and to unite them into a whole. The steps from the destruction of the original vegetation to the resulting stands of weeds and to the reestablishment of the original vegetation are based on general ecological principles and have been dealt with by Piemeisel.[5] The relation of leafhopper populations to the annual weed hosts and to beet yields in southern Idaho has been discussed by Carter[6] and Annand et al.[7] Unpublished data, detailed studies on the changes in plant cover by Piemeisel, and quantitative studies of populations of the beet leafhopper by David E. Fox, of the Bureau of Entomology and Plant Quarantine, also support the statements made.

The original vegetation composed of shrubs, perennial grasses, perennial herbs, and bulbous plants, and hence, free at least of any

FIGURE 5.—A stand of green flixweed in the flowering stage on formerly cultivated land with sagebrush in the background. (Photographed near Hollister, Idaho, June 21, 1932.)

large numbers of annuals, cannot support large populations of beet leafhoppers (figs. 2 and 3). For this there is necessary the sequence of hosts, the annual weeds, discussed on page 2. When the original vegetation over large areas is totally destroyed by plowing and the land is subsequently abandoned, weed hosts appear quickly and soon form a complete cover (figs. 5 and 6). Here, then, is an ideal situation for the development of enormous numbers of leafhoppers. The same is true if the original cover is completely destroyed by trampling and grazing. If there is a partial destruction, that is, if the

[5] PIEMEISEL, R. L. WEEDY ABANDONED LANDS AND THE WEED HOSTS OF THE BEET LEAF HOPPER. U. S. Dept. Agr. Circ. 229, 24 pp., illus. 1932.

[6] CARTER, W. See footnote 2.

[7] ANNAND, P. N., CHAMBERLIN, J. C., HENDERSON, C. F., and WATERS, H. A. See footnote 2.

perennial grasses and perennial herbs that grow among the sagebrush bushes only are destroyed, a growth of spring hosts appears (fig. 4) and with it large spring populations of the leafhoppers.

NATURAL REPLACEMENT OF WEED HOSTS

Where destructive grazing has not taken place on the range and the plant cover has maintained its original stand of perennials, the weed hosts are few (fig. 2) and leafhopper populations are low. The same is true of lands that, once broken, are thereafter continuously well farmed. On well-irrigated lands the weeds that are present are not the weed hosts of the beet leafhopper.

After the original vegetation has been destroyed by plowing, burnings, or grazing and a cover of weed hosts has developed, there is a

FIGURE 6.—A tall growth of Russian-thistle on abandoned land. (Photographed near Berger, Idaho, in October 1934.)

natural tendency for the original vegetation to reestablish itself (fig. 7). The perennials of the original vegetation gradually reseed the area of weed hosts. Although the latter rapidly colonize and soon completely cover an area, they cannot compete with the native perennials, and so the weed hosts are gradually replaced. Usually there is an intermediate stage of annual grasses, chiefly downy chess (*Bromus tectorum* L.) (fig. 8) that first replaces the weed hosts and is in turn replaced by the native perennials (fig. 9). Neither the latter nor the downy chess are breeding plants of the beet leafhopper and, as the weed hosts are replaced, the populations of this insect dwindle to insignificance.

However, the process just described can take place only if there is not too great disturbance of the vegetation. Thus, it is obvious that, if the initial destructive agency is repeated, a stand of weed

hosts again appears. Or if downy chess had finally replaced the weed hosts and the grass stand were then destructively grazed or burned, the weed hosts would again appear.

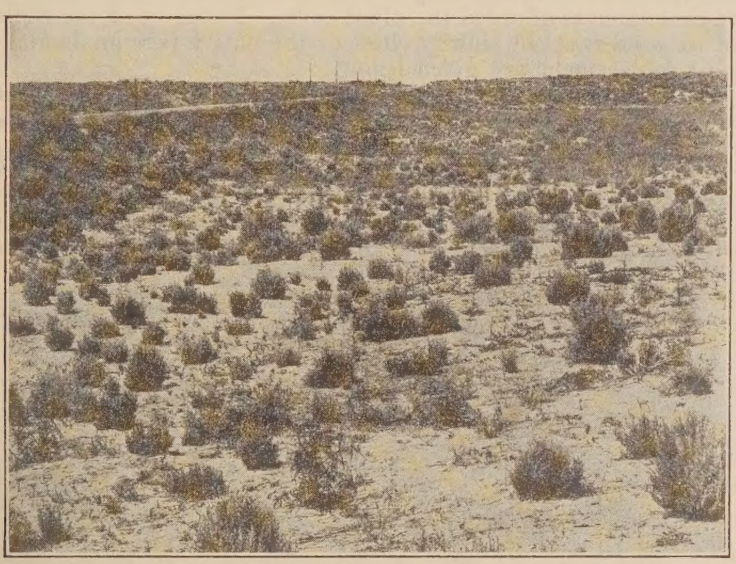

FIGURE 7.—Sagebrush reestablishing itself on a clearing made along a highway. (Photographed near Wendell, Idaho, June 26, 1935.)

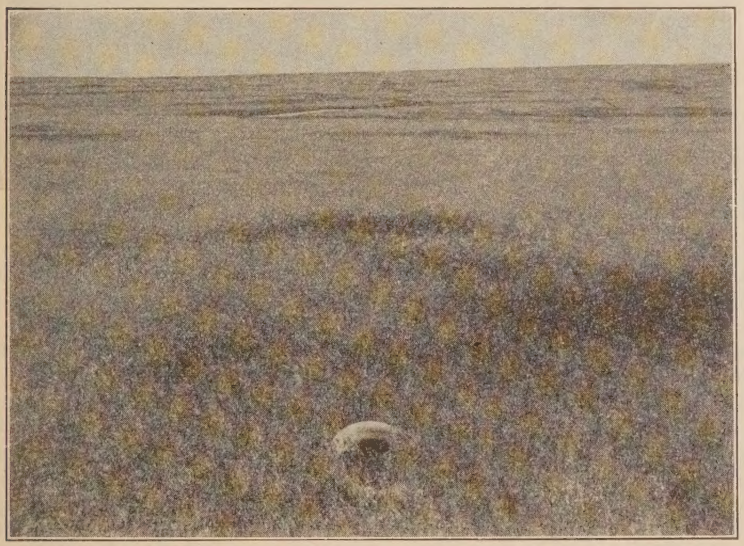

FIGURE 8.—A large area of downy chess on cleared sagebrush land. In the lighter areas the downy chess has matured and dried. In the dark areas, along water channels, depressions, or rodent mounds, the grass still has the deep purple color which precedes the final drying. (Photographed near Hansen, Idaho, June 16, 1935.)

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Under present conditions, without control of grazing or of the repetitive plowing on intermittently farmed lands, the reestablishment of the original vegetation takes place slowly and irregularly. It is rapid and complete only in the more isolated tracts or where some protection is afforded the plant cover. Instances of the replacement of weed hosts by downy chess or the native perennials and the rate of replacement are given below.

Field 4, near Hollister, Idaho, illustrates the rate of replacement by downy chess. The first year of abandonment (1928) there was a widely spaced growth of tall weed hosts, chiefly Russian-thistle, in barley stubble. A dense growth appeared the next year. By 1930, Russian-thistle had been replaced by flixweed, and by 1932 the latter disappeared and downy chess covered over 94 percent of the field. To date, downy chess forms the cover. The field was not fenced and

FIGURE 9.—Sagebrush reestablishing itself on abandoned farm land in a stand of downy chess and weeds. (Photographed near Mountain Home, Idaho, June 26, 1935.)

was therefore open to grazing. In this case the grazing was done by transient herds with no prolonged concentration of stock nor the attendant destruction of plant cover. Under conditions such as the above, downy chess can be expected to replace the weed hosts and reduce leafhopper populations to low numbers in 5 years.

Blue Gulch tract, in western Twin Falls County, an isolated area estimated at about 1,500 acres, shows reestablishment of a sagebrush cover (figs. 10 and 11). The area had been plowed and then abandoned in 1919. At the first observations on this tract in 1931, there was a dense cover of sagebrush, the bushes being about the height of the surrounding original stand. There were practically no weed hosts. This was 12 years after abandonment, but judging from the size and density of the sagebrush, it is estimated that there had been no weed hosts for at least the preceding 5 years. If the estimate is correct, sagebrush had reestablished itself and replaced the weed

hosts in 7 years. This took place under favorable conditions, since the area was not subject to destructive grazing, and there were ex-

FIGURE 10.—Complete reestablishment of sagebrush on approximately 80 acres of abandoned land. The small area to the right of the former clearing is still being used as a sheep-shearing corral and is covered with weeds, chiefly Russian-thistle. (Photographed at Blue Gulch, in western Twin Falls County, Idaho, Sept. 5, 1932.)

FIGURE 11.—A detailed view of a portion of the area shown in figure 10, taken on the right margin of the clearing. The stand of young sagebrush is at the left. At the right is the original stand of old sagebrush, apparently denser, but this is due to the larger size of the bushes. (Photographed at Blue Gulch, in western Twin Falls County, Idaho, June 18, 1935.)

cellent possibilities for reseeding from the surrounding original sagebrush stand. As a contrast to this, there is a small area of about 20

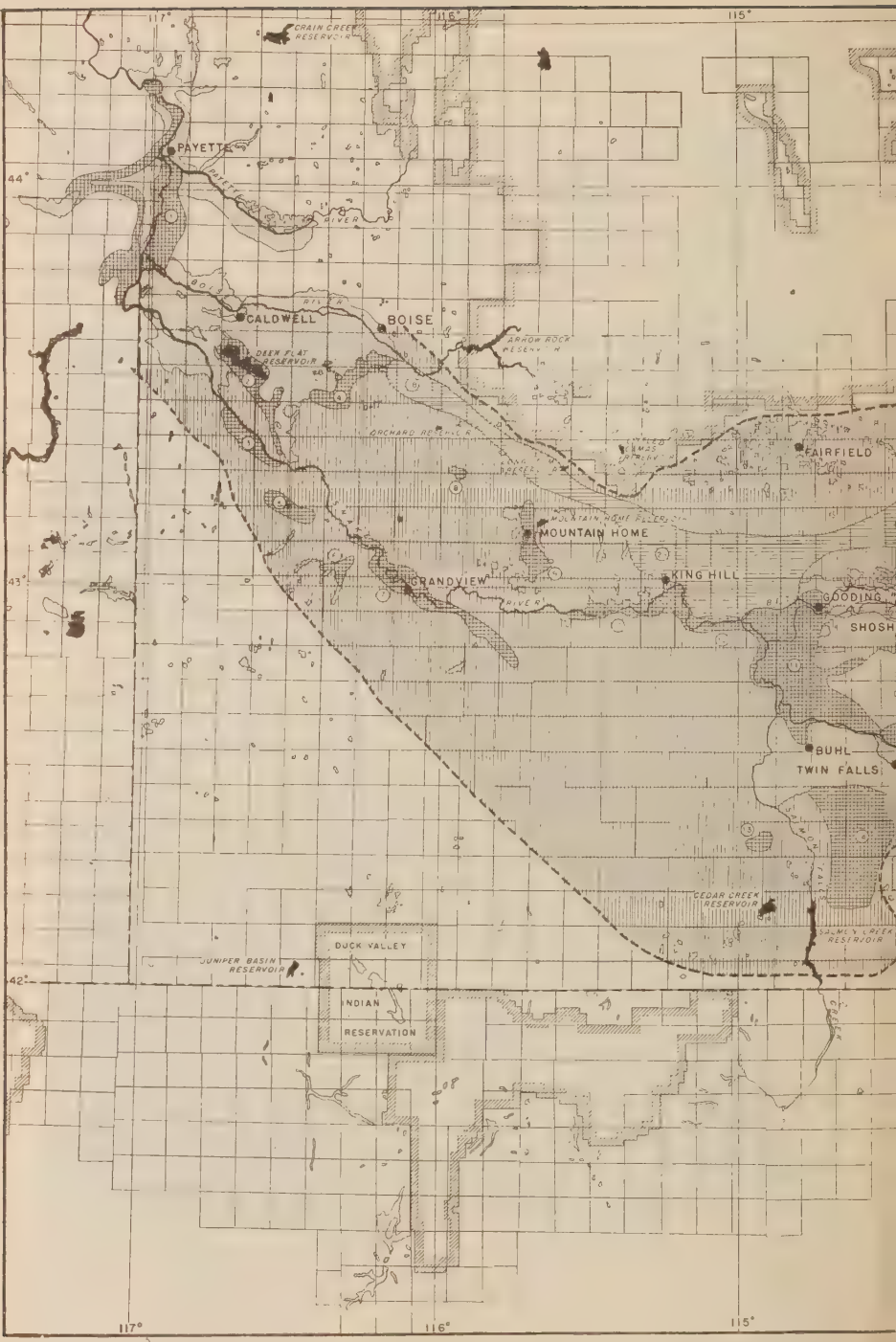
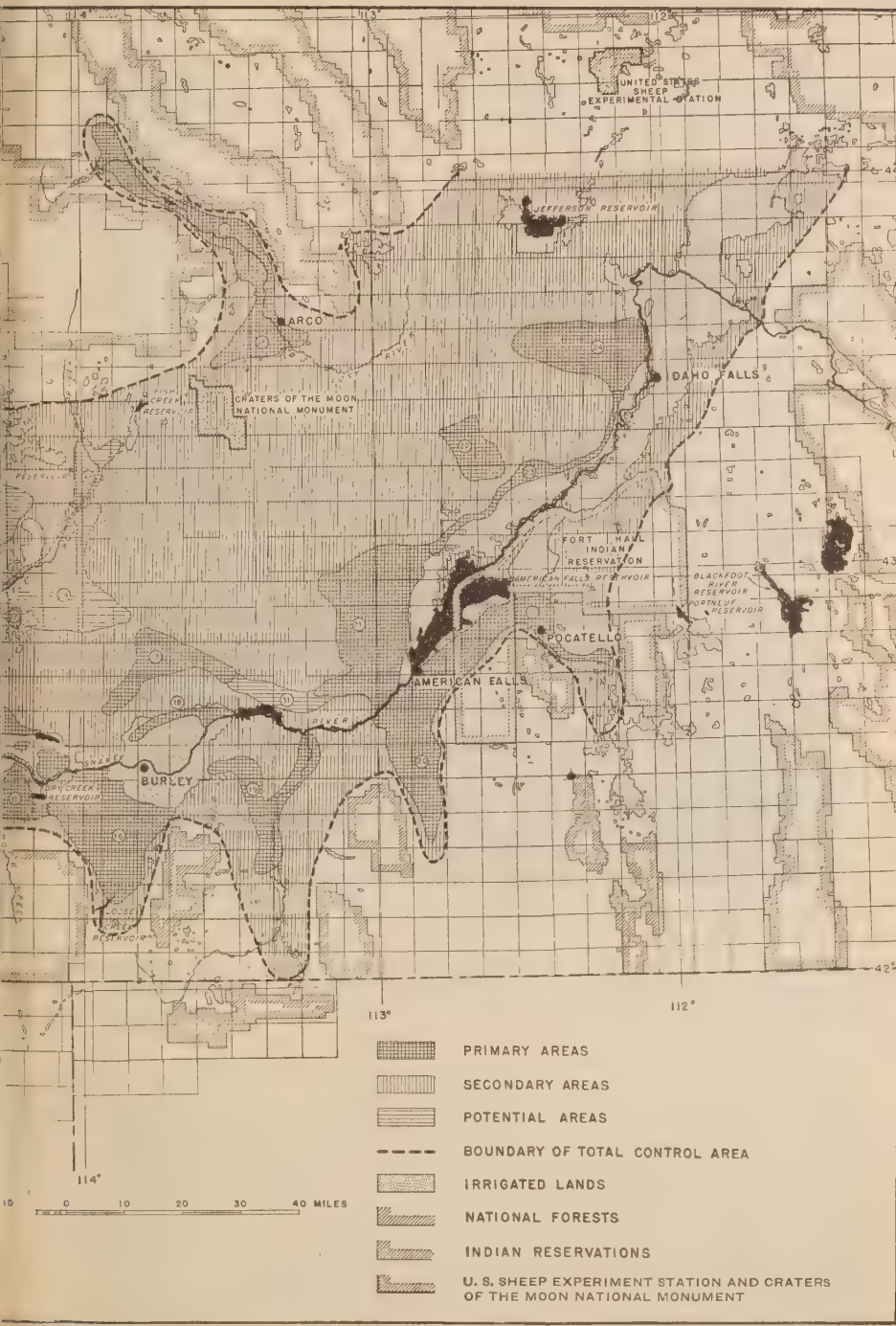


FIGURE 13.—Map of the



ol" area in southern Idaho.

acres at one end of the tract which has been used continuously as a sheep-shearing place. The heavy trampling and grazing here have prevented a growth of sagebrush, and the area is still covered with weed hosts, chiefly Russian-thistle.

There are numerous cases similar to the two above. In the Deep Creek tract (Twin Falls County) there are many abandoned fields now covered with good stands of downy chess or sagebrush where the weed hosts have been replaced and leafhopper populations are low. The rate of recovery varies with the history of the fields. In the less disturbed places the rate is similar to that given above. On other fields where burning and reburning was followed by excessive grazing the weed hosts are still present. There are many

FIGURE 12.—Erosion as a result of the removal of the original vegetation by excessive grazing. (Photographed near Grandview, Idaho, June 26, 1935.)

large abandoned fields in the Kimama-Minidoka area (Minidoka County) that are now covered with downy chess and others with sagebrush.

WEED-HOST REPLACEMENT ESSENTIAL IN LAND IMPROVEMENT

It is evident from what has been said that control of grazing would be highly desirable so as to permit a more rapid and regular replacement of the weed hosts. It should also be pointed out here that there is danger that if destructive grazing be continued in the present weed-host areas even the stands of weed hosts will be reduced to a scant cover over considerable areas or the soil will be laid bare (fig. 12). The cover of annual weed hosts is not a stable one and under continued destructive grazing will degenerate more rapidly than the original cover. It is a fallacious and harmful attitude to assume that the vegetation has been brought to an irreducible mini-

mum and therefore may be grazed in any manner without further deterioration occurring. Such a practice leads to exposure of the soil and rapid soil erosion, a condition notoriously difficult to correct by any ordinary means of revegetation.

EFFECT OF LAND REHABILITATION ON BEET LEAFHOPPER POPULATIONS

In considering the application of the control program it is not necessary to think in terms of eliminating all the areas of weed hosts or of eradicating the leafhopper. It will be necessary only to reduce weed-host areas and leafhopper populations so that the populations will remain at or below the level that exists in successful beet-growing seasons. If all of the weed-host areas are considered—those with uniform, luxuriant stands, those with scattered stands, and those with the plants in poor condition—the total is large. The total leafhopper population, however, is not uniformly distributed over the entire area of weed hosts. Localized concentrations occur. Thus, in the leafhopper survey in the fall of 1934, under the direction of the junior writer, it was found that 63 percent of the total leafhopper population occurred on 30 percent (approximately 560,000 acres) of the total host area (approximately 1,880,000 acres).

Again, severe curly top damage does not occur every year under present conditions. Eleven of the last nineteen beet-growing seasons have been sufficiently free from curly top damage to result in the production of an economically profitable crop. Destructive populations occurred only during eight seasons. Since low leafhopper populations are present even in the most successful of the sugar-beet-growing years, it is not necessary to eradicate the leafhopper but merely to reduce its numbers to the comparatively low level of the 11 successful years. Likewise, to bring about the reduction of the populations to the desired level, it is not necessary to consider the entire weed-host area but rather the portions where localized concentrations of leafhoppers occur.

It follows that control of the beet leafhopper can be accomplished by a rehabilitation of the "desert" breeding areas. Providing the program can be applied on a sufficiently large scale, leafhopper populations can be reduced to a noneconomic level by reducing the available food supply and the number of breeding plants through the substitution of nonhost plant species for the weed host. The steps in rehabilitation are discussed later, but the essentials can be stated here. Since the desert breeding areas are initiated and maintained on the one hand by intermittent, uneconomical farming which permits plowed lands to lie idle and thus favors a growth of weed hosts, and, on the other hand, by destructive grazing which also favors growth of weed hosts it will be necessary to correct these two malpractices.

Such a correction is in keeping with land-conservation policies; namely, the acquisition by purchase or otherwise of lands that cannot be economically farmed; the reinstatement of such lands as part of the public domain and reclassification of them as grazing lands; the control of grazing in such a manner as to prevent deterioration of the soils and to permit the reestablishment and the maintenance of the natural forage. In other words, if the policies definitely recom-

mended for the conservation of land resources were put into effect the leafhopper and curly top problem would become insignificant.

THE PORTIONS OF SOUTHERN IDAHO NEEDING REHABILITATION

GENERAL CONSIDERATIONS

The portions of southern Idaho that need rehabilitating are discussed in the following pages and shown in figure 13. Rehabilitation is discussed as a leafhopper- and curly-top-control measure, but it is obvious that the eventual restoration of the original vegetation is primarily a form of land conservation. Suggestions are made as to the steps to be taken toward rehabilitation in some of the areas, but the consideration of the area as a whole is presented under the heading "Discussion."

For the purpose of this circular the total area needing rehabilitating (that is, the area within the broad dotted lines shown in figure 13) is divided into the three categories given below.

The primary areas are the worst of the weedy areas and are of most importance in the first efforts at control. However, all of these need not be taken into account if only the present sugar-beet-growing districts are concerned, since the classification is based on potential as well as on actual sugar-beet-growing districts. The primary areas include chiefly intermittently farmed and abandoned lands with good stands of Russian-thistle and mustards. It is in areas of this type that the leafhopper normally maintains high populations.

The secondary areas are of less immediate concern and are chiefly overgrazed sagebrush lands. Summer hosts usually are absent, and high populations can be built up only in the spring. Because of this fact the secondary areas are dependent upon the primary areas for their repopulation every fall. In other words, if Russian-thistle could be eliminated from the primary areas, the rehabilitation of the secondary areas would need consideration chiefly from the standpoint of conservation.

The potential areas are of no immediate concern, since weed hosts have been almost entirely eliminated. They comprise chiefly burned-over or old abandoned lands where a partial natural recovery has taken place. At present the most common plant cover is downy chess with or without scattered sagebrush and rabbitbrush. From the standpoint of leafhopper control, protection of these areas is necessary to prevent deterioration of the present cover with the subsequent reentry of weed hosts. The partial recovery that has already occurred emphasizes the fact that primary areas can be controlled in a comparatively short time without a complete restoration of the original plant cover.

The individual areas of the primary and potential categories are listed in table 1 together with information necessary to appraise them for control work. No similar data are available for the secondary areas, but their total extent is given in table 2 along with summarized statements of the primary and potential areas.

TABLE 1.—*Weedy areas of southern Idaho*

[The figures given in the first column refer to figure 13]

PRIMARY AREAS

Key to map	Area	Total area included	Estimated area of Russian-thistle (1934 fall survey)	Original vegetation type	Present plant cover of the denuded portions of the area [1]	
					Hosts	Nonhosts
		Acres	*Acres*			
1	Vale-Parma	113, 700	[2] 700+	Sagebrush	Russian-thistle	Not important.
2	Deer Flat-Melba	30, 600	3, 700+	do	Russian-thistle, tumblemustard.	Do.
3	Wilson-Givens Springs.	18, 100	([3])	Shadscale, greasewood.	Russian-thistle, *Bassia*.	Do.
4	Boise-Kuna	26, 300	([3])	Sagebrush	Russian-thistle, tumblemustard.	Downy chess.
5	Murphy	15, 700	[4] 7, 000	Shadscale, greasewood.	Russian-thistle, *Bassia*.	Not important.
6	Oreana	5, 700		do	do	Do.
7	Bruneau-Grandview.	52, 500	[4] 8, 000	do	do	Do.
8	Sunnyside	2, 500	([3])	Sagebrush	Russian-thistle, tumblemustard.	Downy chess.
9	Mountain Home	20, 800	2, 500	do	do	Do.
10	King Hill-Glenns Ferry	48, 700	2, 100	do	do	Do.
11	Tuttle-Buhl	181, 100	20, 000±	do	do	Young sagebrush, rabbitbrush, downy chess.
12	Falls City-Eden-Hazelton.	62, 800	4, 000±	do	do	Young sagebrush, downy chess.
13	Roseworth	7, 900	7, 400	do	Russian-thistle	Downy chess.
14	Hollister-Rogerson.	140, 700	47, 000	do	Russian-thistle, tumblemustard.	Downy chess, young sagebrush.
15	Rock Creek-Murtaugh.	29, 000	3, 300	do	do	Downy chess.
16	Oakley	164, 300	70, 000	Sagebrush, shadscale, greasewood.	do	Young sagebrush, giant wild ryegrass.
17	Minidoka-Kimama.	72, 600	25, 000	Sagebrush	do	Downy chess, young sagebrush.
18	Rupert-Paul	15, 300	2, 700	do	do	Downy chess.
19	Raft River	76, 500	31, 600±	Shadscale, greasewood, sagebrush.	Russian-thistle	Not important.
20	American Falls-Pocatello.	211, 700	C4, 400	Sagebrush	Russian-thistle, tumblemustard.	Downy chess.
21	Aberdeen	206, 300	77, 400	do	do	Young sagebrush, rabbitbrush, downy chess.
22	Taber	46, 700	22, 900	do	do	Do.
23	Moreland-Springfield.	37, 900	19, 800	do	do	Rabbitbrush, young sagebrush.
24	Idaho Falls-Osgood.	109, 100	30, 000	do	do	Do.
25	Lost River	161, 800	30, 000±	Sagebrush, shadscale, greasewood.	Russian-thistle	Not important.
26	Shoshone-Dietrich	14, 800	3, 000±	Sagebrush	Russian-thistle, tumblemustard.	Downy chess.

POTENTIAL AREAS

P 1	Boise-Magic Dam	428, 900	([5])	Grass, sagebrush	Not important	Downy chess.
P 2	Shoshone-Carey	166, 100	([5])	Sagebrush	Some tumblemustard.	Do.
P 3	Carey	32, 700	1, 100	Sagebrush, grass	Russian-thistle, tumblemustard.	Do.
P 4	Minidoka-Wapi	30, 200	([5])	Sagebrush	Some tumblemustard.	Do.

[1] Plants are named only where they cover a significant portion of the area.
[2] Incomplete. The figure given is for the Parma-Fruitland section of this area.
[3] No survey.
[4] 1932 estimate by R. W. Haegele (unpublished). A survey in 1934 of these 3 (numbers 5, 6, and 7) as a single area showed 12,200 acres of Russian-thistle, but no data for the separate areas are available.
[5] Not important.

TABLE 2.—*Total acreages involved in control work in southern Idaho*

Category	Area		Russian-thistle in 1934	
	Acres [1]	Percentage of total	Acres [2]	Percentage of area
Primary areas	1,880,000	16.1	476,000	25.3
Secondary areas	9,150,000	78.3	0	0
Potential areas	660,000	5.6	1,000+	.2+
Total [3]	[3] 11,690,000	100.0	477,000	

[1] Estimated to the nearest 10,000 acres.
[2] Estimated to the nearest 1,000 acres.
[3] In addition there are approximately 1,330,000 acres of cultivated lands in the general control area which have been excluded from the categories listed.

PRIMARY AREAS

LOCATION AND EXTENT

The total area in this category (approximately 1,880,000 acres) is not continuous, but is made up of many small units usually located near farming tracts. These units often include part of the farming area, especially if the land is not continuously well farmed (fig. 13 and tables 1 and 2).

ORIGINAL VEGETATION

The original vegetation of these areas was for the most part the sagebrush type. The Bruneau-Grandview (7), Wilson-Givens Springs (3), Murphy (5), Oreana (6), and Raft River (19) areas were partly covered by sagebrush, but portions of each of these were originally covered by greasewood and shadscale.

WEED HOSTS

The primary areas have been denuded of the original vegetation principally by farming. About one-fourth of the total included acreage is covered by Russian-thistle in the summer and a considerable acreage is covered by tumblemustard and flixweed in winter and spring. This combination makes these areas ideal breeding grounds for the beet leafhopper. The survey of September 1934 showed that 73 percent of the total female beet leafhoppers in the control area occurred on Russian-thistle in the primary areas. Thus if the Russian-thistle of the primary areas had been controlled in 1934, the total population would have been reduced approximately three-fourths. The remaining populations occurred on sugar beets and on many small scattered stands of Russian-thistle in cultivated sections or in the two categories to follow.

PROBABILITIES OF RECOVERY IF GRAZING IS CONTROLLED

The rate of recovery will vary greatly, depending upon the original type of vegetation and on the damage already done to the topsoil. On the whole, those areas within the sagebrush type of vegetation can be expected to recover more rapidly than those in the shadscale-greasewood type. The intermediate cover of downy chess develops quite rapidly in the sagebrush type under favorable conditions.

This has already occurred to a considerable extent in some of the areas, although not yet to a sufficient degree to advance the status of the particular area from the primary to the potential category. Such partial recovery has taken place in the Hollister-Rogerson (14), Minidoka-Kimama (17), Aberdeen (21), and Taber (22) areas. There is no intermediate downy chess stage between the weed host and the shrub stages in the shadscale-greasewood type. Therefore, a complete recovery to the shrub stage will be necessary before the weed hosts are eliminated, and recovery will be slower.

The possibilities of aiding the recovery in the primary areas by means of plantings are good in the sagebrush type, either by using downy chess as a temporary nurse crop or by plantings of sagebrush and perennial grasses directly. Sagebrush, Sandberg bluegrass (*Poa secunda* Presl), and streambank wheatgrass (*Agropyron riparium* Scribn. and Smith) are readily transplanted, and they can also be seeded. Transplanting and seeding have not been tried in the less important shadscale-greasewood type.

SUGGESTIONS FOR HANDLING CONTROL OF GRAZING

A more stringent control of grazing is necessary in the primary areas than in the secondary or potential areas if the desired recovery is to be expected. However, in general, acquisition and consolidation of lands will be necessary before control of grazing can be put into effect. This is especially true of the Hollister-Rogerson (14), Oakley (16), Aberdeen (21), and Idaho Falls-Osgood (24) areas, and to a less extent in the others. Grazing in primary areas must be prohibited until recovery is well under way. After this they can be handled as ordinary range lands. Once these lands are covered by downy chess they will be of little importance as far as leafhopper control is concerned, providing the stand be protected against deterioration.

SECONDARY AREAS

LOCATION AND EXTENT

The secondary area, comprising about 9,000,000 acres, takes in all the territory in the total control area not included in primary and potential areas or well-irrigated agricultural lands. It extends the full length of the Snake River Plains and also includes the lacustrine benchlands of the lower Snake River Basin in western Idaho (fig. 13 and tables 1 and 2).

ORIGINAL VEGETATION

The secondary areas were, for the most part, originally covered by the sagebrush type of vegetation. A comparatively narrow zone fringing the Snake River west of Bruneau was covered with greasewood (*Sarcobatus vermiculatus* (Hook.) Torr.) or shadscale (*Atriplex confertifolia* (Torr. and Frém.) S. Wats.). A small part of the Raft River Valley was also covered by this type.

WEED HOSTS

The greater part of this area is covered with a stand of sagebrush mixed with varying amounts of green tansymustard which grows

among the sagebrush plants. It is an overwintering and spring breeding area of considerable importance, especially in those portions which fringe the primary areas.

PROBABILITIES OF RECOVERY IF GRAZING IS CONTROLLED

This area can be expected to recover rapidly, since the elements of the original vegetation are still present and afford plants for reseeding the area.

SUGGESTIONS FOR HANDLING CONTROL OF GRAZING

Year-around grazing should be prohibited and late-spring grazing discouraged.

POTENTIAL AREAS

LOCATION AND EXTENT

Not all areas conforming to the category designated as "potential" have as yet been mapped, but those indicated are the most important (fig. 13 and tables 1 and 2). The total acreage included within the boundaries of the areas actually shown is roughly 660,000 acres.

ORIGINAL VEGETATION

The original vegetation was of sagebrush or grassland types. In the Boise-Magic Dam section (P 1) it is probable that most of the area was of the grassland type except along its southern borders. The remaining areas were of the sagebrush type. With the partial exception of the Shoshone-Carey area (P 2), burning, with subsequent excessive grazing and trampling, was the principal cause of the denudation. In the Shoshone-Carey area some of the denudation resulted from unsuccessful attempts at farming.

WEED HOSTS

Weed hosts of the beet leafhopper are few, since downy chess forms a nearly complete cover over most of the potential areas. However, small patches of Russian-thistle and tumblemustard do occur in the neighborhood of the small scattered cultivated sections, especially in the Shoshone-Carey area.

PROBABILITIES OF RECOVERY IF GRAZING IS CONTROLLED

The intermediate stage of downy chess now prevalent makes this area of no immediate concern for leafhopper and curly top control. Complete recovery of the potential areas is likely to be slow in many places, due to the nearly complete destruction of the native perennials, but with adequate control of grazing and fire and some efforts in the way of reseeding and transplanting, relatively rapid improvement should occur.

SUGGESTIONS FOR HANDLING CONTROL OF GRAZING

Grazing should be so restricted as to permit the downy chess stands to persist in good condition. If this is done, the establishment of more desirable forage plants, especially native shrubs and perennial grasses, will be accelerated.

DISCUSSION

In the following proposed practices and operations, which appear necessary in order to accomplish leafhopper and curly top control, there are none that have not already been included under one or another of land-conservation measures.

The objective, rehabilitation of lands, whether for the control just mentioned or for land conservation, is the same, although the results expected may be different, such as increased forage, protection against soil erosion, or the control of the beet leafhopper and curly top. A possible initial difference in proceeding with rehabilitation for the purposes of this control as against rehabilitation for land conservation may be in the importance put on the various areas and the precedence that may be given one area over another when the work is begun. However, if rehabilitation is effected according to one or the other objective, the results would be the same.

The recommendations made here are not contrary to well-founded practices in legitimate agricultural industries, such as farming or stock raising. Although some adjustment in the present practices of each of these will be necessary, this is already contemplated on grounds other than the damage from the beet leafhopper and curly top. No account is taken of the implied legislative and financial problems which will need to be worked out in detail in the actual application of the measures to a given area. Such phases of the problem are beyond the scope of this circular, the purpose of which is to point out that if the measures now contemplated for land improvement are put into effect the result will be a reduction of curly top damage.

The measures proposed for the eventual elimination of the beet-leafhopper-breeding areas involve, on the one hand, eliminating the existing areas, and, on the other, preventing the extension of such areas or the development of new ones.

The steps necessary for eliminating existing areas are as follows: The restriction and ultimate elimination of intermittent farming and the subsequent use for grazing of land so released; the prevention of grazing on the worst of the weedy lands; and the restriction of grazing on the less weedy lands.

Where lands are intermittently farmed, due to an insufficient supply of irrigation water, it may be possible in some cases to develop a greater supply of water and in other cases to consolidate the irrigated tract in such a way that the reduced acreage will be continuously well watered. If neither can be done, the lands will need to be acquired by purchase or trade, classed as grazing land, and treated accordingly. The same would apply to the portions of tracts abandoned as a result of consolidation.

The prevention of grazing is advocated for restricted areas where leafhopper populations are high or where the soil is in such poor condition that even a slight amount of grazing would prevent the replacement of weed hosts by nonhosts. Where possibilities of natural reseeding are poor, the transplanting or seeding of forage plants would hasten the reduction of weed hosts and also hasten the increase in forage value.

Extension of the present weed-host area can be largely arrested by the adoption of the following measures: Grazing should first of all be

sufficiently controlled to prevent the not yet seriously damaged range lands from deteriorating into weedy areas. Secondly, the breaking out of new lands for cultivation should be carefully restricted to prevent an extension of intermittent farming and a resulting increase of weedy areas.

In addition, adoption of the following measures would be helpful: The setting of fires on the desert range should be prevented. Such fires should be regarded as harmful as forest fires. The removal of sagebrush or other desert shrubs for firewood should be so regulated as to permit them to maintain their stands. Rodents or other pests that are destructive to the range or interfere with its rehabilitation should be controlled in the localities where they are very numerous.

The weed-free sagebrush areas do not burn readily, but fires started in weed patches and fanned by a high wind often burn over large tracts of sagebrush, which thus become potential weed-host areas. Cured downy chess burns very readily. Although burning late in the season usually does not in itself destroy the downy chess cover, it results in a thinner stand and invites close grazing and concentrated grazing so that the final result is a reappearance of weed hosts.

Where sagebrush is removed for firewood there usually follows some growth of weed hosts. If only an occasional bush is removed or if the denudation is restricted to small areas there is a rapid reseeding and the weed cover is of short duration.

In areas and under conditions where the above measures are not feasible, the direct removal of Russian-thistle may be a useful supplementary measure.

Even if land-conservation measures cannot be put into effect on such a scale as to eliminate beet-leafhopper-breeding grounds, it is of importance that such measures as can be inaugurated be carried out, even though imperfectly, in order to prevent the future rapid extension of breeding areas and a corresponding increase in the damage resulting from curly top. The opinion of the writers, based on their own observations and also on the many related studies of others on soil erosion and range management, is that the increase in weedy areas, leafhopper populations, and curly top damage will proceed at an accelerated rate if present practices are continued.

SUMMARY

This circular is based upon reconnaissance surveys of weed hosts and leafhoppers throughout southern Idaho and on detailed studies of selected fields and plots. Southern Idaho is discussed in detail to illustrate the problem, but the discussion has been made sufficiently general to indicate the usefulness of the proposed measures in other States.

The beet leafhopper (*Eutettix tenellus* (Bak.)), which is the vector of the curly-top disease of sugar beets, beans, tomatoes, and other cultivated crops, is produced in economic numbers only on the weed-host stands which grow on abandoned, weedy fallow, burned-over, or heavily grazed lands. Well-farmed lands and desert range in good condition do not produce economically significant numbers of this leafhopper.

Under favorable conditions these weed hosts will ultimately be replaced by a combination of desert shrubs, perennial grasses, perennial herbs, and other plants that are not breeding hosts of the beet leafhopper. For the greater part of southern Idaho such complete reestablishment of native perennials is not necessary for the elimination of weed hosts since downy chess, not a host, forms an intermediate stage. In favorable situations the replacement of weed hosts by downy chess takes place in about 5 years.

The portion of southern Idaho here considered is divided into three categories—the primary, secondary, and potential areas. The primary areas are considered the most important leafhopper-breeding areas and are those needing the first efforts at rehabilitation.

The beet leafhopper and curly top can be controlled provided that all lands not continuously farmed and well farmed can be restored to and maintained as good desert range. The measures proposed for the accomplishment of this are similar to those contemplated or now under way for purposes of land conservation and differ only in the results sought for, that is, the control of the leafhopper and curly top instead of increased forage or prevention of soil erosion. Unless present practices are corrected, an increase of the weedy areas, leafhopper populations, and curly top can be expected.

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